

**BIOLOGY AND SEASONAL HISTORY OF *ELASMOSTETHUS ATRICORNIS*  
(VAN DUZEE) (HEMIPTERA: ACANTHOSOMATIDAE), WITH  
DESCRIPTIONS OF THE IMMATURE STAGES AND NOTES ON  
PENDERGRAST ORGANS**

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*Abstract.*—Details of the seasonal history and habits, and duration of the immature stages of *Elasmostethus atricornis* (Van Duzee), a specialist acanthosomatid stink bug on spikenard (*Aralia racemosa* L.; Araliaceae) are presented and discussed. The bug's seasonal cycle is univoltine throughout its North American range, with peak adult emergence nearly synchronous with the first appearance of host plant inflorescences in early July. The egg and five nymphal instars are briefly described, with emphasis on color patterns, and all life stages are photographed. A brief review and illustrations of Pendergrast organs, unique to the Acanthosomatidae, are also provided.

*Key Words:* Hemiptera, Acanthosomatidae, *Elasmostethus atricornis*, seasonal history, immature stages, Pendergrast organs

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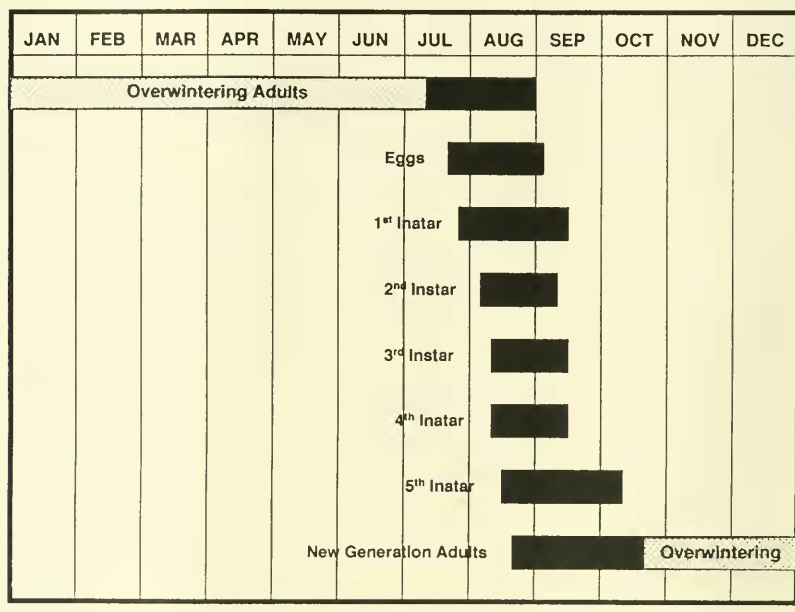
The Acanthosomatidae, a group often considered by earlier workers as a subfamily or a tribe of an inclusive Pentatomidae, comprise three subfamilies, approximately 47 genera, and 180 species worldwide (Kumar 1974, Schuh and Slater 1995). All are phytophagous, feeding on a variety of plants characteristic of mid- to late-successional stages, with several genera feeding upon members of one of the oldest angiosperm subclasses, Hamamelidae (orders Utricales, Fagales, and Hamamelidales) (Schaefer and Ahmad 1987). Six species, three each in the genera *Elasmostethus* Fieber and *Elasmucha* Stal, occur in North America (Thomas 1991).

*Elasmostethus atricornis* (Van Duzee) is known from Montana to Quebec and south to South Carolina (Jones and McPherson 1980, McPherson 1982). Its primary host plant, *Aralia racemosa* L. (Araliaceae), is commonly referred to as

American spikenard, which describes the elongated panicles of fragrant, greenish-white flowers. Leaves are divided and subdivided into 6 to 21 heart-shaped leaflets. It is a perennial shrub often found on ravine banks (Wiegand and Eames 1926), growing 1–2 m each summer and dying back completely in the fall. Maturing fruits (berries) become a deep crimson red to purple in the fall. American spikenard has a geographic distribution somewhat sympatric with that of *E. atricornis*, except the former is recorded farther south to Georgia and New Mexico.

The objective of this study is to document the biology and seasonal history of this little-studied species through field observations over multiple seasons; to photograph its unique habitat, host plant, and various life stages; and to describe and illustrate its immature stages.

Table 1. Seasonal history of *Elasmotethus atricornis* on American spikenard, *Aralia racemosa*, in New York. (Note: Stippled bars indicate period when adults are overwintering in duff and leaf litter, and black bars indicate period when life stages are on host plants.)



#### METHODS AND MATERIALS

The seasonal history of *E. atricornis* was studied at several sites in Ithaca (Tompkins Co.), New York. Observations were made over four seasons, at irregular intervals (but usually every few days) from early to mid July through October, in 1987 and again from 1999 to 2001. The primary study sites included natural areas near Beebe Lake on the Cornell University campus and also along Fall Creek adjacent to the Cornell University Arboretum, and at two local state parks (Buttermilk Falls and Robert H. Treman).

Developmental times were based on laboratory rearing in 2001, maintained at room temperature (ca. 20–22° C) under natural

photoperiod (July–September). Nymphs were placed with spikenard inflorescences and fruits (in aquapics) in plastic boxes. Fruits were changed every 1–2 days, but developmental stages and molts were recorded daily.

#### BIOLOGY

Seasonal history and habits.—The generalized field history (Table 1) of *E. atricornis* is based on populations found on American spikenard in the Ithaca area. New host plant shoots appear by mid May, and by mid July the plant produces large flowering stalks (Fig. 2). Overwintered adults (Fig. 1) began to appear on foliage of American spikenard (Fig. 3) after the plants



Figs. 1-6. The acanthosomatid stink bug *Elasmostethus atricornis* and its host plant, American spikenard, *Aralia racemosa*. 1, Adult feeding on host fruits. 2, Elongated flower panicle of host plant in early July. 3, Typical ravine bank habitat of host plant. 4, Cluster of fifth instars and two teneral adults on maturing fruits of host plant. 5, Aggregation of fifth instars on upper leaf surface of host plant, just prior to molting to new generation adults. 6, Adults clustered on host leaves, prior to overwintering.

produced inflorescences and small, developing fruits. During all years studied, bugs generally were not observed until the first or second week of July. In 1987, adults were first noticed on July 10. In 1999, overwintered adults were seen on July 14, with matings taking place on July 16. Adults were not seen on plants until July 20 in 2001. Soon after they emerged from overwintering sites, adults began to feed, probing flowers and developing reproductive structures; they also sought mates. Soon after mating, egg deposition began. When oviposition began before fruits were available (i.e., late July to early August), eggs were deposited on the lower leaf surfaces, usually arranged (Fig. 7) in small tight clusters of 12–25 eggs, or often as individual eggs. After early to mid August, the majority of eggs were laid on the surface of individual fruits or on the pedicels. Eggs were observed as early as July 22 in 1999 and July 30 in 2000, and females continued to lay eggs as late as September 15 in 2001. Eggs hatched approximately 2–3 days after deposition. First instars, which hatched synchronously in a clutch, were found in the field as early as July 25 in 2001. First instars do not stray from the egg shells (Fig. 8), but remain motionless in place; they apparently did not feed on their host plant during this life stage. After molting to the second instar (Fig. 9), nymphs dispersed to host fruits. Second instars were observed by early August (ca. August 2) in 1999, closely followed by third instars (Fig. 10) and fourth instars (Fig. 11) (August 14 in 2000; August 11 in 2001), and then fifth instars (Fig. 12) (August 15 in 2001). Second through fifth instars fed on fruits after probing with their stylets. Fourth and fifth instars, highly polymorphic in coloration (Figs. 4–5, 11–12), often clustered among the maturing berries (Fig. 4), where they were essentially camouflaged by the very similar fruit shape and coloration (Aldrich 1988); this crypsis might protect the nymphs from predation. Fifth instars often aggregated on upper leaf surfaces, in fold-

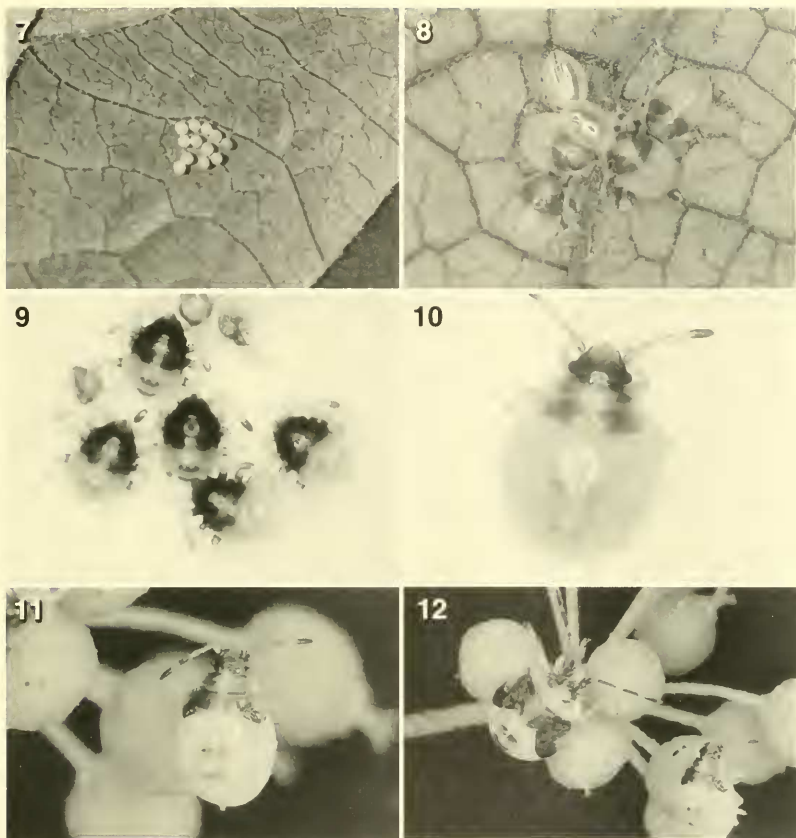
ed-over leaves, and in large numbers just prior to adult eclosion (Fig. 5). Adults also clustered on leaves in the fall (Fig. 6). Adults of the new generation began to appear by late August (August 23 in 1987 and 2001) and continued to appear until early to mid October (October 7 in 2001 and October 11 in 1999). In 1999, new adults were present as late as October 19. By late October, or after the first hard frosts, most adults disappeared from host plants, presumably having moved to overwintering sites in and under the deep leaf litter below and around the senescing hosts, as observed for *E. interstinctus* (L.) in Alaska (Barnes et al. 1996). Only a single generation was produced annually in central New York, as is the case elsewhere in its range in North America (Jones and McPherson 1980).

Duration of immature stages.—In the laboratory at 20–22° C ( $n = 6$  egg clusters observed), the incubation time for eggs of *E. atricomis* ranged from 4–6 days after clutch deposition; by contrast, in the field the majority of eggs hatched 2–3 days after deposition. Nymphal development (from egg hatch to adult eclosion) ranged from 11 to 39 days. The earliest appearance of new adults (from egg hatch) averaged 18.8 days (range 11–27) and the latest averaged 32.4 days (range 28–39). Each of the first two nymphal stadia generally lasted 2–3 days, while the third and fourth nymphal stadia required 2–4 days (10–11 days for some individuals). The fifth nymphal stadium averaged 9 days (range 2–14). As in a natural setting, nymphs of all instars remained on the clusters of maturing host fruits throughout the period of nymphal development.

#### DESCRIPTION OF IMMATURE STAGES

Egg (Fig. 7).—Length, 0.88–0.93 mm ( $n = 4$ ); width, 0.64–0.73 mm ( $n = 7$ ). Ovoid, slightly pointed apically, pale translucent green. Red eye spots visible through egg chorion just prior to egg hatch.

First instar (Fig. 8).—Length, 0.97–1.18 mm; width, 0.52–0.98 mm ( $n = 12$ ). Head, thorax, and dorsal plates (= abdominal



Figs. 7-12. Life stages of *Elasmostethus atricornis*. 7, Cluster of eggs on lower leaf surface of *Aralia racemosa*. 8, Newly hatched first instars. 9, Second instars. 10, Third instar. 11, Fourth instar. 12, Fifth instar (left).

scent gland openings) uniformly brownish, except ecdysial lines of head and median line of thorax pale, subhyaline. Eye dark red. Antenna pale brown. Legs pale yellow; tarsi darker. Abdomen uniformly yellowish green.

Anterior wing pads undeveloped. Approximate ratio of lengths along median line of pro-; meso-; metanotum = 4.0: 3.0:

1. Antennomere ratio (approximate) of I: II: III: IV = 1: 1.2: 1.2: 2.2.

Second instar (Fig. 9).—Length, 1.67–2.54 mm.; width, 1.26–1.67 mm (n = 12). Head, thorax, and dorsal plates mostly dark brown to black. Anterior dorsal plate with some reddish highlights. Abdomen pale yellowish. Eye dark red to black. Antenna pale yellow, subhyaline, except basal anten-

nomere infuscated and apical antennomere darkened (reddish black) on apical half or more. Legs pale yellowish, except femora dark brown. Apical tarsal segment (bearing claws) slightly darkened.

Anterior wing pads undeveloped. Approximate ratio of lengths along median line of pro-: meso-: metanotum = 7.1: 4.9: 1. Antennomere ratio (approximate) of I: II: III: IV = 1: 1.2: 1.3: 1.6.

Second instar very similar to first instar, except head and thorax of latter darker; sternal plates of thorax also darkly pigmented as well as femora and tip of rostrum. Distal half or more of apical antennomere piceus or black.

Third instar (Fig. 10).—Length, 2.59–4.75 mm; width, 1.32–3.61 mm ( $n = 11$ ). Head, thorax, and dorsal plates dark brown, except anterior portion of head (including juga and tylus), lateral margins and middle of pronotum and mesonotum, and central portions of dorsal plates (only narrow anterior and lateral margins dark) pale yellowish. Abdomen mostly yellowish green. Narrow darkened anterior margins of dorsal plates with some reddish highlights. Eye dark red or black. Antenna infuscated, basal antennomere mostly dark brown, antennomeres 2 and 3 centrally darkened, apical (4th) antennomere dark reddish brown. Legs blackish brown except bases of femora and middle of tibiae pale yellowish.

Anterior wing pads undeveloped. Approximate ratio of lengths along median line of pro-: meso-: metanotum = 4.5: 4.0: 1. Antennomere ratio (approximate) of I: II: III: IV = 1: 1.5: 1.7: 2.2.

Fourth instar (Fig. 11).—Length, 3.45–5.16 mm; width, 2.73–4.01 mm ( $n = 14$ ). Coloration of head and thorax highly variable, ranging from pale green to blackish. Dorsal plates also variable in color, from pale yellowish to dark reddish brown with reddish and black highlights. Abdominal segments pale yellowish green. Eye generally reddish. Antennomere reddish brown to dark brown to blackish. Legs pale green to

reddish brown; apical tarsal segment generally darker.

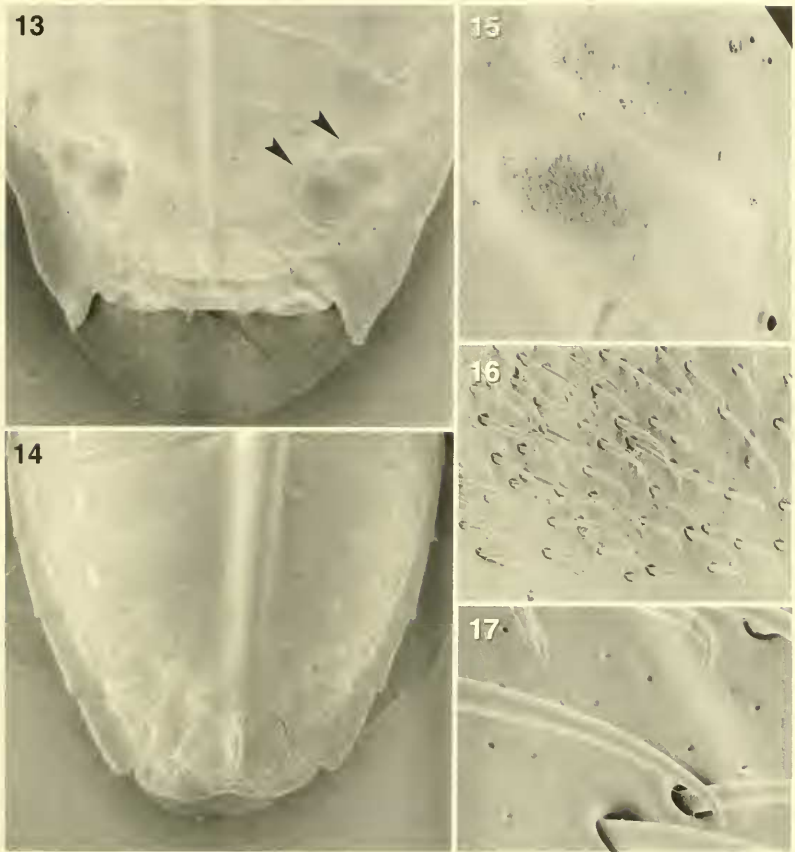
Anterior wing pads developed, attaining posterior margin of metanotum; posterior wing pads undeveloped. Approximate ratio of lengths along median line of pro-: meso-: metanotum = 4.0: 7.1: 1. Antennomere ratio (approximate) of I: II: III: IV = 1: 2.1: 1.8: 2.3.

Fifth instar (Figs. 4–5, 12).—Length, 6.61–8.55 mm; width, 4.54–5.49 mm ( $n = 14$ ). As in preceding instar, coloration of head, thorax, and dorsal plates highly variable. In non-maculated specimens, head, thorax, and abdomen pale yellowish green, except antennomeres reddish to reddish brown, tarsal segments reddish brown, and dorsal plates highlighted with some red and black. In maculated specimens, head and thorax (including well-developed wing pads) variously marked with black. Dorsal plates mostly dark reddish or black around perimeters, greenish yellow centrally. Abdomen generally pale green. Ocelli and eye dark reddish. Antennomeres mostly dark reddish brown. Femora mostly pale greenish; tibiae generally brownish; apical portion of terminal tarsal segment dark red to black.

Scutellum well developed, attaining posterior margin of metanotum. Anterior wing pads highly developed, extending to third or fourth abdominal tergite. Posterior wing pads conspicuously developed. Approximate ratio of lengths along median line of pro-: meso-: metanotum = 13.7: 20.7: 1. Antennomere ratio (approximate) of I: II: III: IV = 1: 1.8: 1.9: 1.7.

Note: Beginning with the fourth instar, which is nearly synchronous with fruit ripening (fruits become dark red to purple), and continuing with the fifth instars, the dorsal coloration is generally highly variable, with pale morphs of mostly yellowish green with no dark markings to maculated morphs with red and black highlights on the head and thorax, including dark red, brownish or black wing pads. Late in the season (September into October), this variable dor-





Figs. 13–17. Scanning electron photomicrographs of abdominal venters of acanthosomatid adults. 13, Abdominal venter and Pendergrast organs (arrows) of *Elasmostethus cruciatus*. 14, Abdominal venter of *Elasmucha lateralis*. 15, Close-up of Pendergrast organs on sterna 6 & 7 of *E. cruciatus*. 16–17, Magnification of setae (16) and cuticular pores (17) of the Pendergrast organs of *E. cruciatus*.

sal coloration makes nymphs difficult to see among the ripening fruits on which they feed (see Fig. 4).

#### PENDERGRAST ORGANS

Pendergrast organs, structures on the abdominal venter of females only, are unique to the Acanthosomatidae. They have been

used as one of the characters defining 26 genera (Kumar 1974), although a similar structure exists in at least one other hemipteran family, the Lestoniidae (Fischer 2000). In observing the oviposition behavior of *E. atricornis*, we found that the female, after depositing an egg, brushes each hind tarsus alternately and repeatedly

against the Pendergrast organs, followed by an apparent tapping of the egg. This sequence of behavior was repeated 5–10 times continuously for 30–60 seconds. Pendergrast (1952) noted similar behavior for the New Zealand species *Rhopalimorpha lineolaris* Pendergrast.

In both *E. atricornis* and *E. cruciatus* (Say), the Pendergrast organs are circular, depressed areas located laterally on the sixth and seventh abdominal sterna, a pair of depressions on either side of the midline (Fig. 13). Under high magnification, these depressed cuticular areas are clothed with short setae (Figs. 15–16) interspersed with minute pores (Fig. 17). Microscopic examination (Breddin 1903, Pendergrast 1953, Carayon 1981, Staddon 1990) and SEM and transmission electron microscopy (Fischer 1994) of cuticular preparations of other acanthosomatid species indicate that the pores are connected by ducts to glandular tissue.

Several hypotheses have been promoted that speculate on the function of the Pendergrast organs, including their involvement in copulation (Breddin 1903, Pendergrast 1953), in pheromone production (Staddon 1990), and in the secretion of compounds that deter egg predation (Aldrich 1988, Fischer 1994). Acanthosomatids in genera that lack Pendergrast organs instead brood or guard their eggs and young. For example, females of *Elasmucha lateralis* (Say), a common North American acanthosomatid in which Pendergrast organs (Fig. 14) are absent, exhibits brooding behavior. Females of *E. lateralis*, and those of other species in this worldwide genus, guard their eggs, first instars and sometimes later instars (Frost and Haber 1944; Kudô 1990, 2000; Kudô and Nakahira 1993; Kaitala and Mappes 1997).

#### DISCUSSION

The absence of apparent feeding in first instars and the late-season appearance of overwintered adults are not unique to *Elas-*

*mostethus*. These biological attributes are shared by other heteropteran taxa.

Lack of feeding by first instars is not unusual among pentatomomorph Heteroptera. In many instances, first-instar nymphs of seed-sucking species, such as the southern green stink bug (*Nezara viridula* (L.)), the rice stink bug (*Oebalus pugnax* (F)) (Bowling 1979, 1980), and the green stink bug (*Acrosternum hilare* (Say)) (Simmons and Yeargan 1988), remain clustered on the eggs shells and do not feed on plant tissue; however, occasionally the nymphs have been observed probing the egg shells with their stylets. First instars of many predatory pentatomids (subfamily Asopinae) do not feed, or feed only on unbatched eggs of their own species (Wheeler 2001), such as *Euthyrhynchus floridanus* (L.) (Oetting and Yonke 1975), *Podisus maculiventris* (Say) and *P. placidus* Uhler (Mukerji and LeRoux 1965, Oetting and Yonke 1971), and *Stiretrus fimbriatus* (Say) and *S. anchorago* (F) (Oetting and Yonke 1971, Waddill and Shepard 1974). Some first-instar coreoids also do not feed (Pupedis et al. 1985). For example, first instars of *Leptoglossus fulvicornis* (Westwood), a magnolia fruit-feeding specialist, do not feed or do so only minimally on foliage (Wheeler and Miller 1990), while first instars of *L. occidentalis* Heidemann, the western conifer-seed bug, often are able to reach the second stadium without feeding (Koerber 1963).

Several heteropterans also are characterized by the late-season appearance of overwintered adults. Wheeler and Miller (1990) documented that the coreid *Leptoglossus fulvicornis* overwinters in the adult stage in Pennsylvania and remains in hibernation sites until mid-June to early July at which time adults then colonize host trees when small, cone-like fruits begin to appear. Other specialist Heteroptera that overwinter as adults and do not become active until late in the season when inflorescences or developing fruits of their host plants are available include the lygaeid *Ochrinus mimulus* (Stål) (Palmer 1986) and the pentatomid



*Proxys punctulatus* (Palisot de Beauvois) (Vangeison and McPherson 1975).

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